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Barriers to upward communication in the U.S. Navy

Chapman, Jean L.

REAL-TIME PROCESSING AND MANAGEMENT INFORMATION SYSTEMS

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by

Charles B. Chapman

Lieutenant Commander, United States Navy

Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

IN

MANAGEMENT (DATA PROCESSING)

United States Naval Postgraduate School

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ABSTRACT

Management information systems were introduced and it was shown how they may be implemented using real-time computer systems at great benefit to the user. A comparison was made between the conventional system and the real-time system in terms of the processing of individual transactions.

The various equipment that may be used in such systems was analyzed in terms of its application to a designed real-time system for any specific application.

Some of the disadvantages of the real-time system were pointed up such as, the possible disrupting of the organizational structure and previous methods of conducting business.

The system described herein provides for the immediate access to stored information as well as the immediate processing of inputs through the use of on-line remote units.

ACKNOWLEDGEMENTS

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A MANAGEMENT SYSTEM

"Our reasoning grasp at straws for premises and float on gossamers for deductions." Alfred North Whitehead.

Introduction

In a very short span of time the technological developments in the data processing field have opened new vistas for the development of sophisticated management information systems. One of the most noteworthy outgrowths of this vastly improved technology is the development and increasingly sophisticated use of "real-time" computer systems.

At this point, let us begin by defining the management information system as envisioned in this paper.

A management information system is a collection of procedures, equipment and persons associated together for the purpose of providing managers, who have the authority to make decisions that commit the firm or its resources, with descriptions of the elements relevant to the performance of their function.[1]

Management Systems and Design

As a result of resourcefulness, courage, dedication and hard work changes in management forms and functional procedures have been created that make the task of managing easier with the passage of time.

[1]Miller, James C. "Conceptual Models for Determining Information Requirements." AFIPS Spring 1964.

[illegible]

To properly keep pace with the increasing potential of organizational operations, the hard work of the past is being continually transformed by the powerful forces of science and technology. This can be borne out by an analysis of the techniques utilized by industry and the military services, of which some examples will be given in Chapter III.

In operational activities, such as on production lines, the use of automatic machines has become mandatory for economic survival. Just as the production areas of industry have utilized computers for the furtherance of economical production and more effective utilization of men, machines, and material so also must those in the management field use the tools available to automate some of the processes requiring management decisions and control. This step is essential if management is to perform its functions in the most efficient manner to derive maximum benefits for the firm.

It should be pointed out that if management elects to utilize the data processing potential available, it will not only possess a new capability to control the system in depth, but will be required to control in depth if the use of automatic processing techniques are to be employed advantageously. In the past the data processing systems of management were limited in functional scope in that they were solely clerical in nature. They were clerical in the true sense of the word in that computers were not available with their sophisticated programs for updating information records automatically. The clerk handled and manipulated all inputs giving

management a desired output only after lengthy processing of the input. The scope of management systems has been greatly broadened thereby increasing the complexity of the problem of design.

Systems design for automatic data processing involves a thorough knowledge of what should be done in each phase of the system. Decisions must be made, based upon this knowledge, as to specific procedures to be carried out by each person involved in the operation of the system. It must be pointed out here that initially in the process of a system design no one can possibly know precisely what should be accomplished at all points in the system. In order to achieve an understanding of the system desired, there must be a harmonious flow of information between the designers of the system and the users of the end product.

The automatic processing system must be an intergral part of a management system and not just a means for automating existing procedures. Functional experience in the areas to be automated must be considered with a view to the new input requirements. New reports must be designed, new data for the reports must be collected, new personnel assignments must be made as the older personnel retire or transfer to more secure havens, and new organizational relationships must be established in the dynamic system designed. Experience must be further augmented from the management viewpoint in that new management criteria must be identified and communicated to all echelons of control. It is also necessary that an understanding of the meaning and use of those criteria be developed and communicated to the existing personnel. In systems design,

we must be concerned not only with how people ought to behave but how they will behave in a given management structure. Because of depth, scope and complexity of any systems design its development must be carried out in a very systematic manner.

In the course of developing systems for the purpose of automating operations it is likely that a great many problems will be encountered. Of the more difficult problems it can safely be stated that none of them are insuperable. This stems from the fact that most problems encountered in the design of management systems are man-made in the first place.

Problems of Systems Design

In general, problems created in the management field will usually develop in one of three ways. There are those problems that arise out of a need to create a management system where a vacuum existed before, e.g., control of a new organization. There are problems that arise out of a need to redesign an existing management system in the light of changing management objectives; and finally, there are those problems that arise out of a capability to manipulate information toward almost any desired end and to which end systems analysts can be profitably directed. This last problem area is the one of concern in this paper in that it reflects a condition imposed by the increased potential of automatic processing techniques. The systems designer must examine the comprehensive objectives of management in order to develop a system which will put management in such a position that all routine tasks are

routinely controlled and the exceptions are easily handled.

Authority is an essential aspect of this development. The major problem encountered here will be to determine how the procedural questions are to be resolved by those with the authority and knowledge required for their resolution.

> The goal is to design a general purpose system which is capable of satisfying a large class of unspecified requests. Such a system must recognize that the structure of the process which it must carry out is not sequential in nature.[2]

Some of the many problem areas that will be encountered in the determination and design of a management information system arise because the effective system tends to cross departmental lines. This is necessary to ensure that there is no duplication of effort and that the computer facilities are being utilized in the most effective manner. There are, however, many manual operations and data manipulations that are best left as manual operations. Some such operations might involve the infrequent use of a file, e.g., once a year, for the purpose of adding to the file. To avoid the pitfall of putting too many unnecessary operations in the computer system continued use of such files should be considered. The design of the system should involve a fresh look at the basic information processing requirements with the major emphasis slanted toward improved customer service, better management control, and overall, a more effective use of the present physical facilities.

[2] Fitzwater, D. R., & Schweppe, E. J., "Consequent Procedures in Conventional Computers," AFIPS Spring 1964.

Some development problems encountered arise from the imperfect understanding and appreciation on the part of the operators (as well as the managers) of the power and scope of the new techniques. The new environments in which the automated clerical operations must live as well as the new organizational and personal relationships are also problem factors. The corresponding lack of perception of their limits and deficiencies as well as the characteristic suspicion of the unknown on the part of all concerned also contribute to the problem areas.

It is only natural to predict that the problems will be multiplied as one tries to apply automatic processing techniques to management operations which rely apparently on human processes as opposed to, say, production control systems. The development of automatic management systems cannot succeed without personnel capability and organizational authority to span the vast scope of organizational structure.

Systems Input

One of the relevant questions for management in this computer age is: "What is top management deriving from the presently installed computer system?" How many managers have taken a good hard look at the reports spewed out of a high speed printer and asked themselves: Does anyone really have time to read all the reports ejected from the printer? These are representative of the questions asked in the book <u>Electronic Business Systems</u> by Richard Sprague (Ronald Press, 1962). The answers to some of these management questions

may be found after a careful and thorough analysis of the potential of a data processing system. The system envisioned in this paper to be used for the management processes should virtually eliminate the mountains of paper reports currently generated and seldom used in the present system.

As is evident in any system devised, the outputs are never any better than the inputs. The old phrase "Gargage in, garbage out" is especially true when electronic computers are introduced into a management system.

The use of computers will go a long way toward alleviating some of the problems encountered, such as data being too voluminous to be processed with available resources, but may at the same time intensify other problem areas.

The chain of activities leading up to the input of data to a processor is as follows:

1. Events occur and are detected or observed.
2. Observed events are translated into symbols.
3. Symbols are recorded as data.
4. Data are converted into processable form.
5. Processable data are transmitted to the processor.

The recorded data must be converted to physical form. Figure 1. depicts the flow of information between the users and the processor.

The major purpose of a management data processing system is to provide management with information that describes the operation in terms of output that is immediately usable and aids in the decision-making process.

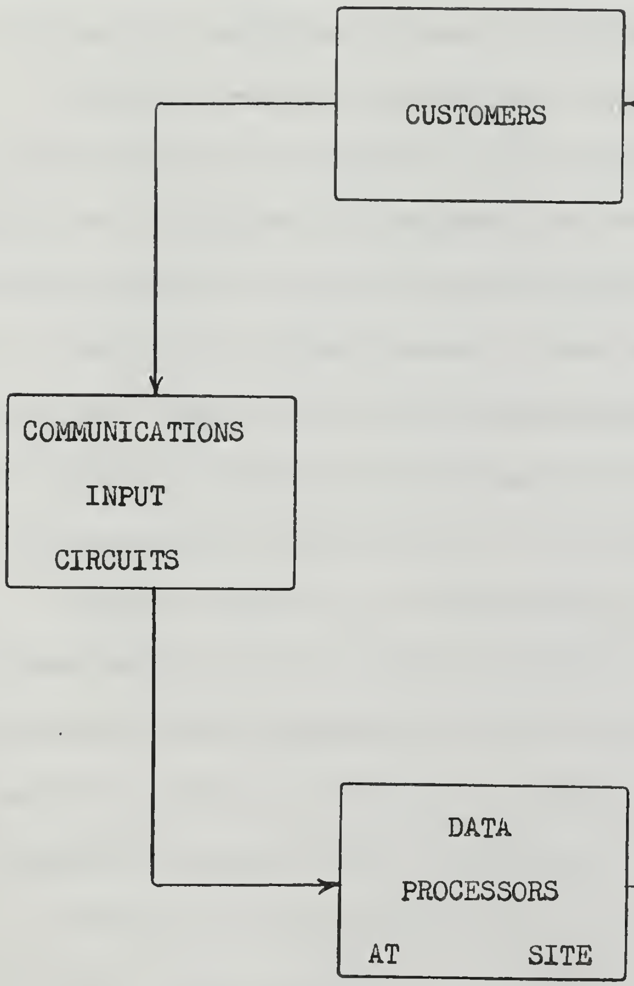


Figure 1. Data Flow Between Users And Data Processors.

The determination of the reporting of specified events is a complex problem faced by management and it is management's ability that determines what information is required. Usually there will be a trade-off between the cost of obtaining information and the usefulness of that information.

Much has been said and written about "exception reporting". In the design of an effective system there will be many events that will not be required by management and should not be generated as routine inputs to a data processing system, but should be assumed as occurring in a normal manner. A word of caution is in order in that many times one will find when designing a system that overemphasis on exception reporting may cause certain reports to be eliminated which later turn out to be of major interest to the system.

Once the events to be reported have been specified by the system designer and the desired information about the events specified, the system designer must then describe the specific process that will result in the proper interpretation of the event.

Equipment Selection (Some considerations)

The type of processing required influences the selection of the input-output equipment. Random-sequence processing is preferable when file-update cannot be scheduled, when quick updating is wanted, and rapid reply to interrogations is needed.

The selection of data recording and transmitting equipment should be considered on the basis of: (a) the equipment reliability, (b) volume of recorded information, (c) data input time

requirements, (d) major costs associated with data input equipment, and (e) design features of data input equipment.

When current information is of such a critical nature that for successful management decisions and for automatic control of operations to be realized the use of on-line input and output devices are imperative.

Network installation and operating costs help determine how much geographical centralization is desirable.

The system designer should so design the system that the amount of computer input is minimized. Also, the system must be flexible enough so that changes in the volume of data can be properly handled. If the current system is not capable of handling the increased volume, the designer must either change the number of input devices or possibly redesign the system.

Users Equipment (Other considerations)

In conventional computer applications the method of entering information regarding transactions affecting items in the files usually involves the filling out of a transcript sheet before transferring the information to a punched card. In both transcribing operations above there is the probability of an error arising through erroneous transfer of data.

The logical approach to be employed in the designed system will be to allow the operator to access the central files directly through remote equipment instead of indirectly, through the medium of punched cards.

The equipment itself must be easy to operate by the personnel who initially will not be familiar with data processing devices. A limited amount of training should be provided to the user so that the user will be able to use the device properly. The training information should be presented in such a manner that it is simple, clear and concise.

The user should not be able to seriously damage or erase any information that is already in the file. This implies some form of file protection system which must be built-in either as a hardware feature or as part of the software. One of the best ways to control the sporadic transmission of data from several remote units is to use buffers which allow message composition and printing to be accomplished in such a manner that the computer is free for other users. A buffer is a storage device used to compensate for a difference in the rate of flow of information, or the time of occurence of events. Figure 2 depicts a system employing buffers. Imagine that a remote unit initiates a specific inquiry as to the availability of an item of inventory as recorded on the disc file. The remote operator will make this inquiry using the correct format. The buffer, to compensate for operating speed differentials, begins to accept the data from the remote terminal. When the buffer loading operation is complete the information is transferred into the main internal storage of the central processing unit. This transfer is accomplished at a fast rate. The central processing unit accesses the disc file for the requested information and if necessary up-dates

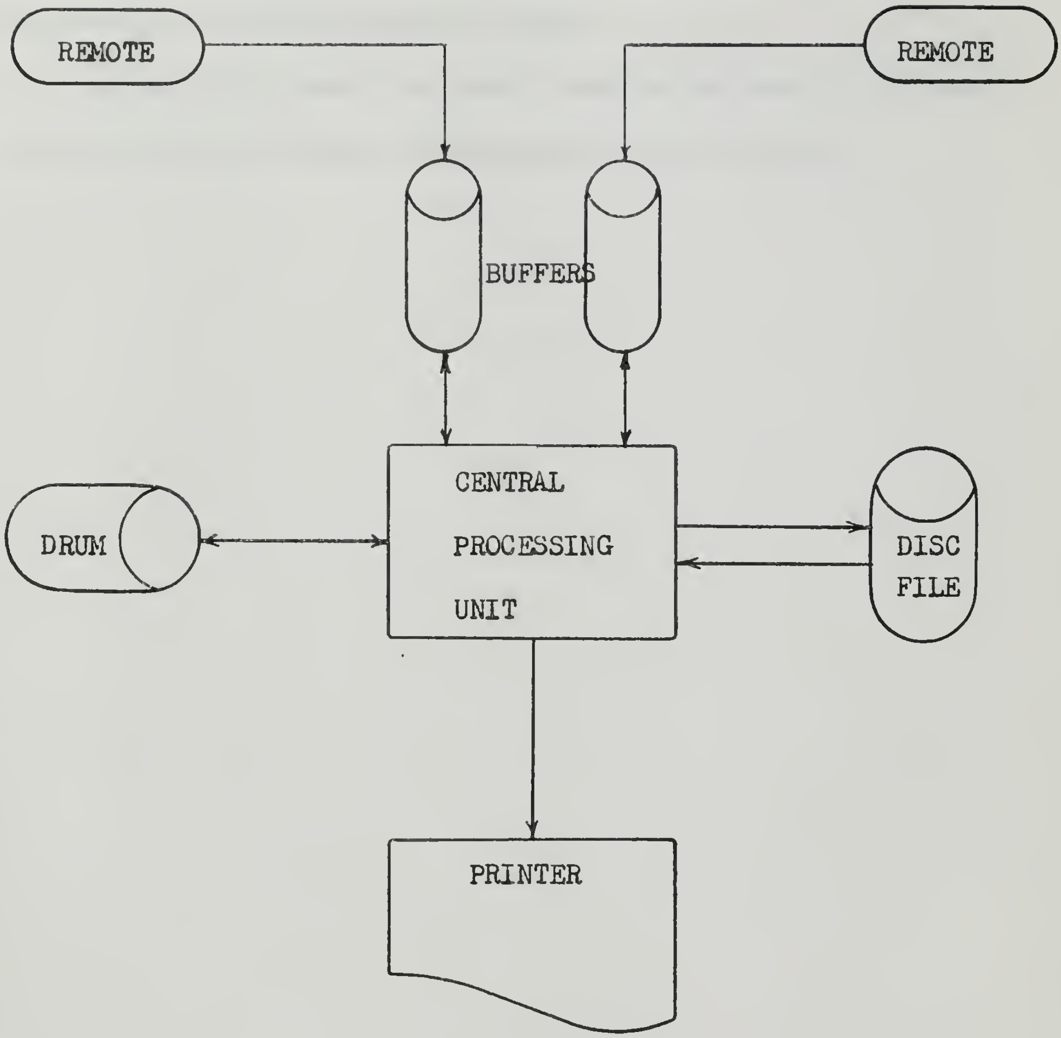


Figure 2. Processing Center

the record. The information is then fed back to the remote unit via the buffer.

Management can benefit greatly from employing real-time processing in the information system.

In the next chapter we shall describe the real-time system and indicate the relative advantages of such a system .

II

REAL-TIME COMPUTER SYSTEMS

One of the very first systems that employed the concepts of real-time was the SAGE (Semi-Automatic-Ground-Environment) System. This command and control configuration consists of a network of communications-based computers tied together for the purpose of evaluating information gathered by radar about all the aircraft in the air over the United States and Canada. If the network determines that an incoming aircraft is hostile it is tracked continuously. At a specified point, the information gathered regarding the flight of the aircraft is fed to a BOMARC missile and the missile is launched. The computer then tracks both the aircraft and the missile feeding corrections to the missile in terms of position, velocity, and strategy of the hostile aircraft. Thus, the SAGE system is so designed that it continually evaluates information received and if necessary, alerts interceptors, assigns targets and dispatches intercepting missiles.

Definition of Real-Time

What is meant by the terminology 'real-time' and what constitutes a 'real-time system'? There are many definitions that may be gleaned from the myriad of articles and books written and published on the subject.

Sperry Rand states in their descriptive literature on the UNIVAC 490 real-time computer, that "just as feedback is used by a

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

computer to control a missile's path and counteract disrupting forces, up-to-the-minute data from a real-time system can help an organization influence the course of a number of its business curves as they are formed."[1]

"Real-time" is an adjective which is often used to describe systems involved, for example, in production control, communications-switching, or banking transactions. A "real-time system", we shall define, as a system that keeps pace with a live operation. The live operation is involved with the then current transaction and the manipulation of the information generated by that transaction which will result in an updating of the files. The current transaction is considered to be an input from a user capable of directly accessing the stored files through remote units. The system envisioned accepts data on a continuing basis with a minimum of manual intervention for the purpose of converting input data into a form acceptable to the computer. A further requirement of this definition of "real-time" is that the output information, whenever called for, will be current and in a usable format. Of course, it is still true that in almost every business system there are continuing requirements which can be met by slower and less expensive equipment, such as payroll preparation and the filing

[1] "The UNIVAC 490 Real-Time System, General Description," Sperry Rand Corporation, 1961. P.1.

of claims. On the other hand, there are also many requirements for immediate response such as, status reporting in answer to a query for a specific item in stock from a sales office in the field. The desired real-time system must be able to distinguish priorities of needs and satisfy each one of the needs as fast as is desired. Real-time processing involves the collecting, processing and using of data while the associated event is in progress. Even in a real-time application a sequence of events may proceed slowly, relatively speaking. Thus, it can be stated that real-time is not necessarily synonymous with instantaneous physical time although the appearance to the user may be that of an instantaneous response.

To properly develop a real-time system for management a determination must be made of the requirements for continuous processing. The value to management of up-to-the-minute information and rapid response to customer demands must be critically appraised.

There is a vast difference in the time-requirement for the computer if it operates on a cycle basis in contrast to operating as a real-time system that must process each specified transaction as it occurs. The term cycle basis as used herein means that a number of transactions are batched and then processed during a specified period of time. If the computer is operating on-line, that is, its operational inputs are fed directly to the central processing unit, or in the context used herein in "real-time",

a transaction is processed as soon as it is available to the computer by virtue of the input-output devices having direct access to the computer. An 'on-line system' is usually defined as a system which minimizes the need for human intervention between source data recording and the ultimate processing by the computer. An 'off-line system' on the other hand is a system in which human operations are required between the original recording functions and the ultimate data processing function. This includes conversion operations as well as the necessary loading and unloading operations incident to the batch-processing data systems.

A real-time system is designed to accept many kinds of data simultaneously and to process the data on a transaction-by-transaction basis as it arrives. Transaction reporting then is really a characteristic feature of the real-time system. It eliminates the lag between the occurrence of transactions and their posting to the master file. The master file contains the records which comprise the entire firm's activities and is as its name suggests, the controlling or life-blood file of the system or firm.

Most real-time systems are required to process events which are asynchronous, unscheduled and unpredictable as to their time of arrival and transmission.

> The on-line system is usually subjected to many short duration demands in the micro-seconds to seconds range. In the automatic system where the demands occur at intervals in the micro-seconds range, practically all of the processor's capacity must be devoted to servicing the demands ... The response to

the demand, however, is usually measured in milli-seconds. Thus, there is excess capacity in the processor which can be used to perform other tasks.[2]

An on-line system as depicted in Figure 3 consists of one or more central data processors with a multiplicity of remote but directly-connected input and output terminals which provide a quick and uninterrupted flow of input and output. The remote input-output stations, when connected on-line to the central computer, are capable of immediate access to any information stored in the computer files. Usually each equipment subsystem of the composite system is continually and crucially involved in the operation. In an intergrated on-line data processing system all remote input-output devices are tied directly to the data processor.

Characteristics of Real-Time Systems

Some of these characteristics have been developed because of the competitive pressures which have been brought to bear on computer manufacturers for improvements in computer hardware and basic systems design as well as to better serve the user's needs. Improvements that have been incorporated in the real-time system give the system its distinctive properties. The characteristics include: random-access capability, development of sophisticated point-of-origin devices, and improvements in communications networks.

[2]"Programming On Line Systems," Frank, W.L., W.H. Gardner & G.L. Stock, Datamation, May 1963.p.32

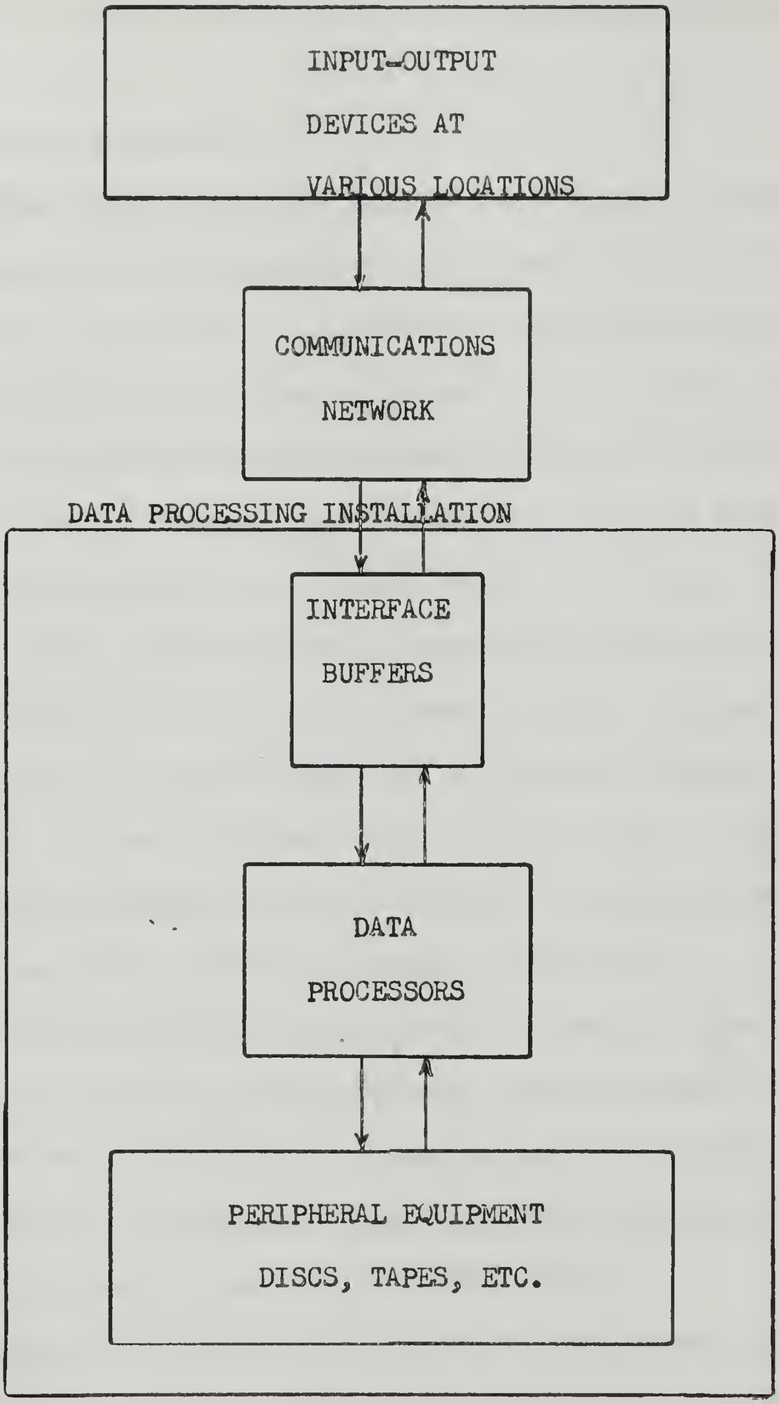


Figure 3. Major Components of an On-Line System

Each of these characteristics will be analyzed to observe its contribution toward a more complete description of real-time systems.

Random-Access Capability

Random-access capability implies the ability to randomly store and retrieve bits of information. Such media permit direct access to specific stored bits of information without the need to examine sequentially all data stored in the same file. Random-access data storage also implies a multi-dimensional storage of bits of information either in internal core storage or in special high speed storage units external to the main computer processor. The most common storage units utilized are drums, where the data is stored on the surface of a revolving cylinder and disc storage, where data is stored on a flat disc similar to a phonograph record.

Both are memory devices with low access times. A mass memory device is an external storage device that provides a large capacity, is relatively fast, and random-access in character.

The term "external" distinguishes it from the "internal", or central, core memory of the computer. When we speak of mass memory we are referring to storage capacities in excess of 10 million bits of information. (Most immediate access core memories have capacities of a few million bits.)

In order to utilize the advantage of fast access time the memory devices must be operating on-line and under direct control of the processor. In a large system with multiple interrupt lines,

a mass memory will permit rapid access to information.

In the design of the system we are concerned with the capacity, average access time, data transfer rate, cost, and addressing techniques of the mass memory devices to be used.

Figure 4 is a table which presents a gross comparison of various mass storage devices. For a specific application the selection of a device would involve a much more detailed comparison of the specific pecularities and costs of the leading devices if the correct selection is to be made. One may see by looking at the column headed "Typical On-Line Costs In ¢ per Character" that the larger the number of bits that can be accessed by a single head and selection mechanism, the lower the cost per bit.

Random-access capability has proved to be a boon to organizations which previously maintained large files of information on punched cards or on magnetic tape. Additions to or deletions from the files required sequential searches of the file items until the correct position was reached. This sequential search also applied in the case of inquiries. For the uses cited above, the search time or tape handling time was the limiting factor to improving the system. The random-access file allows the user to go directly to the item of interest and greatly speeds up file maintenance operations.

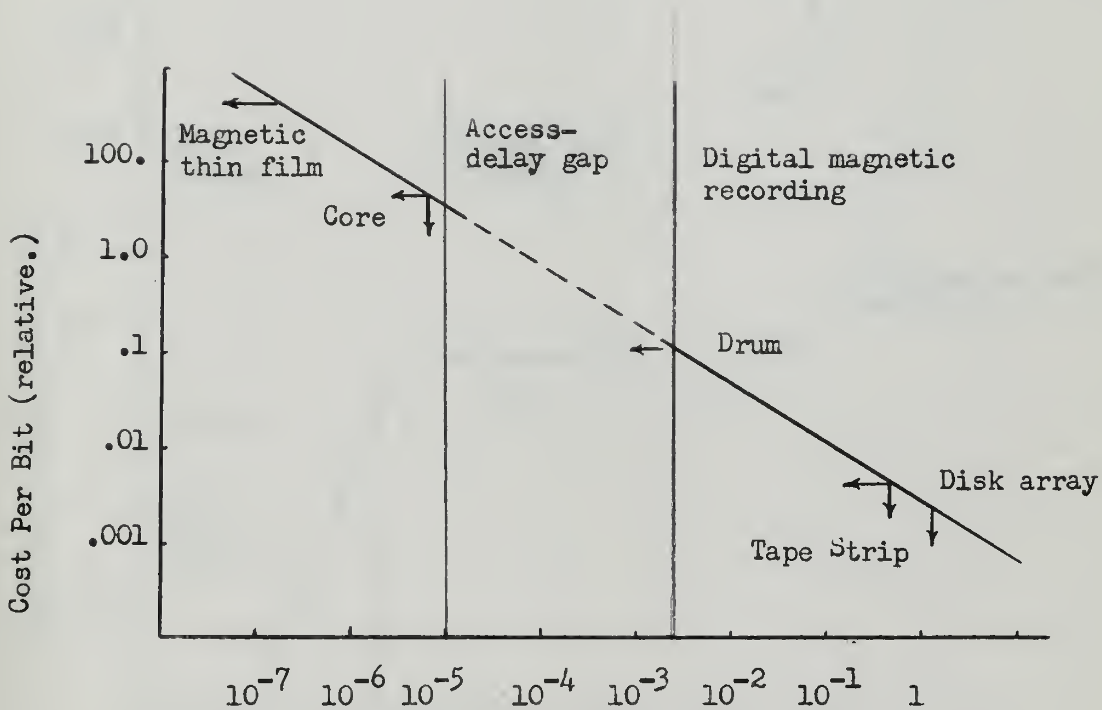
From an analysis of Figures 5 and 6 it is apparent also that as we reduce the access time we increase the cost per bit in the system. Similarly as we reduce access time we also cause a

TYPE OF DEVICE	ON-LINE CAPACITY PER-UNIT IN CHAR.	TYPICAL ON-LINE COSTS IN ¢/CHAR.	AVERAGE ACCESS TIME	DATA TRANS-FER RATE IN CH/SEC.	REMOV-ABLE MEDIA	MULTIPLE ACCESS CAPA-BILITY	MAJOR ADVAN-TAGES	MAJOR DISADVAN-TAGES
MAGNETIC TAPE LOOPS	50×10^6 to 500×10^6	0.1	8 sec.	20,000 to 100,000	YES	NO	LOW COST	VERY SLOW ACCESS
LARGE FIXED-HEAD MAG. DRUMS	0.2×10^6 to 1.0×10^6	2.0	15 ms	100,000 to 200,000	NO	POSSIBLE	FAST ACCESS	HIGH COST, LOW CAPACITY
MOVING-HEAD MAGNETIC DRUMS	4.0×10^6 to 65×10^6	0.3	100 ms	50,000 to 150,000	NO	NO	LARGE CAPACITY, LOW COST	MEDIUM SPEED ACCESS
FIXED-HEAD MAGNETIC DISC FILES	10×10^6 to 25×10^6	0.6	20 ms	100,000 to 350,000	NO	POSSIBLE	FAST ACCESS	HIGH COST
1 DIMENSION MOVING-HEAD MAG. DISC.	10×10^6 to 150×10^6	0.2	100 ms	100,000 to 400,000	NO	POSSIBLE	LARGE CAPACITY, LOW COST	MEDIUM SPEED ACCESS
2 DIMENSION MOVING-HEAD MAG. DISC	10×10^6 to 150×10^6	0.15	500 ms	50,000 to 100,000	NO	NO	LARGE CAPACITY, LOW COST	SLOW ACCESS
REMOVABLE-STACK DISC FILES	2.0×10^6	1.2 (on-line) 0.02 (off-line)	150 ms	80,000	YES	POSSIBLE	LARGE OFF-LINE CAPACITY, LOW COST	SMALL ON-LINE CAPACITY
MAGNETIC CARD FILES	5.5×10^6	1.0 (on-line) 0.003 (off-line)	200 ms	100,000	YES	NO	LARGE OFF-LINE CAP., LOW COST, DISCRETE CARD	SMALL ON-LINE CAPACITY
* WOVEN SCREEN MEMORY	1.0×10^6 to 10×10^6	9.0	10 us	100,000	NO	NO	FAST ACCESS, NON-MECH.	HIGH COST, NOT CURRENTLY AVAILABLE

* Note: All figures shown for Woven Screen Memory are estimates of future developments.

Figure 4. Summary of Characteristics of Mass Memories.

AFIPS Conference Proceedings, Fall 1963. p. 302.



Arrows show trends in mass memory

Figure 5. The Cost/Access time trade-off

International Science and Technology "Storing Computer Data"
By Albert S. Hoagland. January 1965, p. 52.

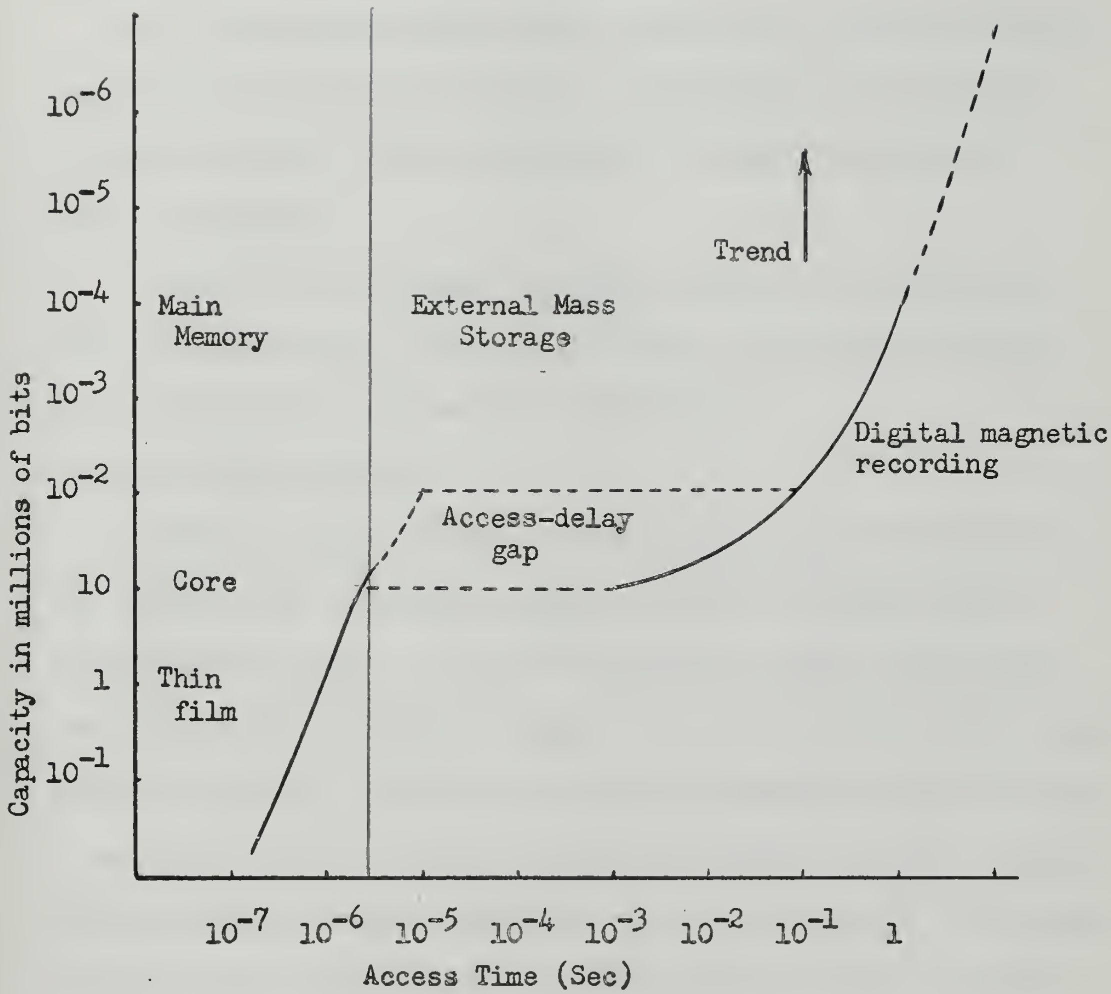


Figure 6. The Capacity/Access time Trade-Off

International Science and Technology, "Storing Computer Data" By Albert S. Hoagland. January 1965, p. 52.

reduction in the capacity of bits that can be stored in a particular system. Therefore, we realize that the system must be analyzed and then designed with these trade-offs in mind to derive the optimal system for a given application.

The random-access file allows substantial savings of time to be realized in the area of sorting, collating, and multiple processing runs which were all necessary to arrange the data for batch processing.

Some of the advantages and disadvantages of the different types of mass memories compared in Figure 4 are given in Figure 7 as a summary of random-access capabilities.

Point-of-Origin Devices

Point-of-origin devices are input-output units connected to the central data processing complex by wires or other direct communication links. In a total real-time system, every person, machine, or other point-of-origin in the organization having a true need to originate, receive or utilize information is provided with a suitable device. Usually each device permits two-way communications with the central computer. The device should be installed at the user's normal physical location and should be tailor-made to the organization's needs.

A system in which transactions must be handled as they occur, usually has the master file kept in addressable bulk storage for on-line processing. Point-of-origin devices are connected directly to the processor for handling transactions as they occur.

TYPE OF MASS MEMORY	ADVANTAGES	DISADVANTAGES
Fixed-Head Magnetic Drums	Fast access, no mechanical head motion, high continuous data transfer rate	Low capacity, high cost per bit, poorer volumetric efficiency, large electronic switching matrix, large number of heads
Moving-Head Magnetic Drums	Large capacity, low cost per bit, possibility of parallel reading or writing from multiple heads to greatly increase instantaneous data transfer rate	Poorer volumetric efficiency, relatively large number of heads for medium speed access or slower access if fewer heads
Fixed-Head Magnetic Discs	Fast access, medium capacity, no mechanical head motion, high continuous data transfer rate	High cost per bit of storage, large electronic switching matrix, large number of heads
Two-Dimension Moving-Head Magnetic Discs	Large capacity, minimum number of heads, low cost per bit	More complex positioning mechanism, slowest access, slow continuous data transfer rate
One-Dimension Moving-Head Magnetic Discs	Large capacity, possibility of multiple simultaneous accesses if heads are positioned independently, low cost per bit compared to fixed head units, possibility of parallel reading or writing from multiple heads to greatly increase instantaneous data transfer rate	Relatively large number of heads, somewhat higher cost per bit compared to two-dimension disc unit, medium speed access
Removable-Stack Discs	Large off-line capacity, low cost per bit of off-line storage, combines on-line random-access capability with large off-line capacity	Limited on-line capacity, higher cost per bit of on-line storage
Magnetic Card Memory	Large off-line capacity, low cost per bit of off-line storage, combines on-line random-access capability with large off-line capacity, individual cards can be copied, replaced, or inserted.	Limited on-line capacity, higher cost per bit of on-line storage
Woven Screen Memory	Fastest access, no mechanical motion	Lower capacity, higher cost per bit, not currently available

Figure 7. Summary of Advantages and Disadvantages of Mass Memory.

AFIPS Conference Proceedings, Fall 1963, p.306.

Input preparation devices are used for recording and converting data. Some examples of input devices that may be used will be given below.

Tags such as inventory tags may be designed to provide direct input to the processor via tag readers. A portion of an inventory tag may be detached and placed in a transaction recorder at the point of transaction. Such a transaction could be a sale to a customer, the issue of a part to the manufacturing department or the shipment of a part to another activity. The recorder automatically reads the tag and produces a direct input to the processor or a continuous punched tape. The input data also includes variable information that the operator enters manually on a keyboard. The tape can be converted on a periodic basis or fed directly into a processor for inventory, sales and customer accounting. Direct wire transfer of data from the transaction recorder to a processor is useful for updating accounting balances fast enough to permit interrogating them about current inventory status.

Another input device is the data collection unit which can be located strategically in production centers of a factory. These devices can be used to collect data about factory operations. Machine-readable identification cards or tags can be prepared once for each machine operator and each machine. When a job is started, the operator inserts three cards - man, machine, and job - into the reading device in his production center. The data are read and transmitted to a central unit that records the input data. When an

operator completes a job he repeats the input cycle and then enters the quantity produced via a keyboard on the reading device.

On-line punched card readers are used with many business processors. The processor controls the card reader. Conversion between the punched card code and the code used in the processor is handled by the input equipment, ordinarily with no loss in processor speed.

A console keyboard may be used to enter data directly into the processor's storage. Keyboards can be used for program testing, program alteration and file interrogations.

Keyboard input may be desirable in some applications. Keyboard input inquiries are restricted to files in magnetic core storage, drums, or disks on-line to the processor. Interrogation devices can be located in remote locations if suitable communication links are provided.

Desk sets are special purpose input units designed for speed and accuracy in applications that require frequent access to large files, such as in airline reservation systems.

A large number of these units may be connected to the processor at one time. Data from each keyboard are accepted in a scheduled order by the central processor but priority may be given to some keyboards to accept their input ahead of the others.

On-line devices also convert processor output directly to magnetic tape, punched cards, paper tape, printed reports or visual displays. The desk sets mentioned earlier usually operate as on-line direct display output units.

Large processors may employ a cathode ray output device to display data either directly from the processor or from magnetic tape. On-line scopes might be useful for quick display of information wanted by managers.

Communications Networks

The recent advances in the area of data transmission have made possible the use of remote data processing units. The main advances have been made in the area of speed of transmission and in increased reliability of operation due to automatic fallback paths, repeat facilities, and extensive error checking devices.

The transmission of data to the processor is the last stage of input prior to data read-in. In some applications such as factory data collection, remote keyboard, or special set inquiry units, transmission is an inherent part of the recording and conversion operations. However, communications arises as a separate facet when the transmission stage is not integrally related to data origination.

Currently many commercial types of data transmission services are available. Among them are Data-Phone, Wide Area Telephone Service, Wide Area Data Service, and Telepak all offered by American Telephone and Telegraph, and Broad-Band switching from the Western Union Service.

The Data-Phone system utilizes the standard telephone transmission lines. Each time the service is used, the input station dials the receiving station. Rates are on the same basis as normal telephone communications.

The Wide Area Telephone Service is similar to the Data-Phone System but the charges are on a flat-rate basis. The Wide Area Data Service is similar but only data may be transmitted and the rates are cheaper than those of Data-Phone and Wide Area Telephone Service.

The Telepak service provides multi-channel private leased-lines. The rates depend upon the number of channels used and the length of the line. The Broad-Band Switching Service of Western Union is similar to Telepak in function and rates charged.

With appropriate conversion equipment, the regular telephone and telegraph networks may be used as needed at standard rates. Circuits are classified mainly by their capacity which is the rate at which they are able to transmit data. Teletype is of low capacity, telephone is of intermediate capacity and microwave or the Telepak service is of high capacity.

The regular commercial telegraph service is used to transmit limited amounts of data. Teletypewriter Exchange Service (TWX) provides dialed connections between any two points on the network. Maximum rate of data transmission over a telegraph grade circuit (exclusive-line lease) is ten characters per second.

Standard voice or telephone channels will transmit data at rates up to several hundred characters per second depending on the type of service. For example, circuits leased for exclusive use by one customer may have a maximum rate of 300 characters per second while circuits in the dial network may have a maximum rate of 250

characters per second for local service and 150 characters per second for long distance service. Telepak service is available on a leased circuit basis in several grades at data rates up to 60,000 characters per second. Transmission techniques for all circuits are improving and maximum rates are expected to increase in the future.

Some companies, such as North American Aviation Company in the Los Angeles area, have set up private microwave systems which are capable of high-speed transmission rates of millions of bits per second. However, since relay stations must be within ten to twenty miles of each other, numerous stations make installation expensive enough to limit widespread private use of such systems.

The amount of system operating costs is an important factor to be considered. The operating costs will run for the life of the system. Some costs are directly related to the equipment in use such as, equipment maintenance, machine operators and supporting personnel, power, air conditioning, tapes, and supplies. Other costs are more directly related to the particular data-processing system in use such as, methods used for data origination and communication, systems analysis, systems design, programming, and analysis and design to extend existing applications and to add new ones. To the foregoing costs should be added costs of personnel indirectly related to the system but whose activities are affected by it, such as, production and marketing personnel.

The cost of terminal equipment is not insignificant and must be considered in the design of the system. Such costs mount rapidly with the number and the geographical dispersion of the terminals. For example, relatively uncomplicated visual display units vary from approximately $10,000 to $50,000 while keyboard printers usually cost around $15,000 for the first unit. For example, the IBM 1050 unit, in common use in real-time systems, comprises a 1051-2 control unit costing $3,050 and a 1052-1 printer costing $2,725. The transmission control device is a 1026-1 which sells for $10,800.

Figure 8 shows how the relative cost per computer operation has been declining since the introduction of the first commercial computer, the UNIVAC I. Any improvement in information in the management system is reflected in improved operations, e.g., through smaller inventories on hand and better service to the customer.

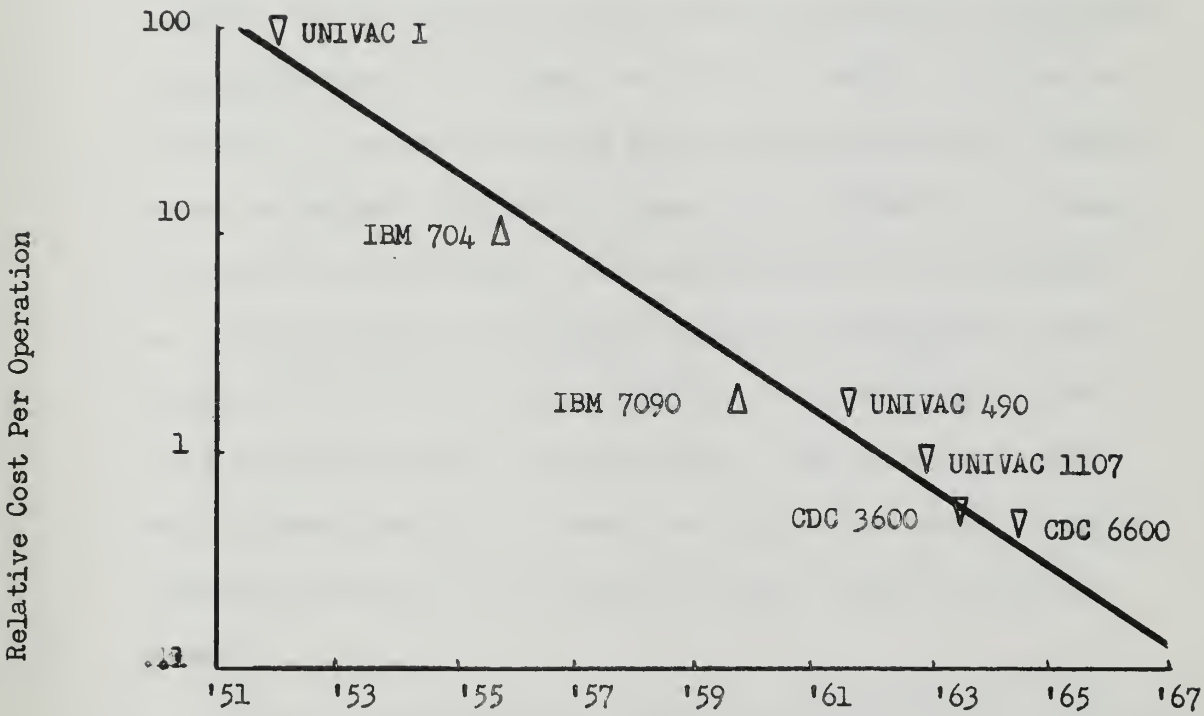


Figure 8. Cost of Computer Operation.

III

MULTI-PROCESSING

The multi-processing and message switching capability of the real-time system deserves a more detailed description than other characteristics. To properly service many remote locations in real-time, a switching network must continually scan all remote units, determine a desire to transmit, and schedule the communications from each station. The scheduling may be accomplished on a priority basis, but usually involves the sequential transmission of a few bits of data from each station as the system scans from remote unit to remote unit. This allows data from many different sources to enter the computer essentially simultaneously, because of the rapid scan rate, usually in microseconds.

Figure 9 depicts several separate but interrelated processing operations that are carried on simultaneously by two or more computers. In this situation each computer is concentrating upon a particular processing assignment, but is able to communicate with the other computers.

Here three real-time applications are shown with inputs for two jobs filtering through one multiplexor and input for the third job filtering through the other multiplexor. In case of a breakdown of one multiplexor the other unit could handle the inputs from all three applications, but at an obviously slower rate.

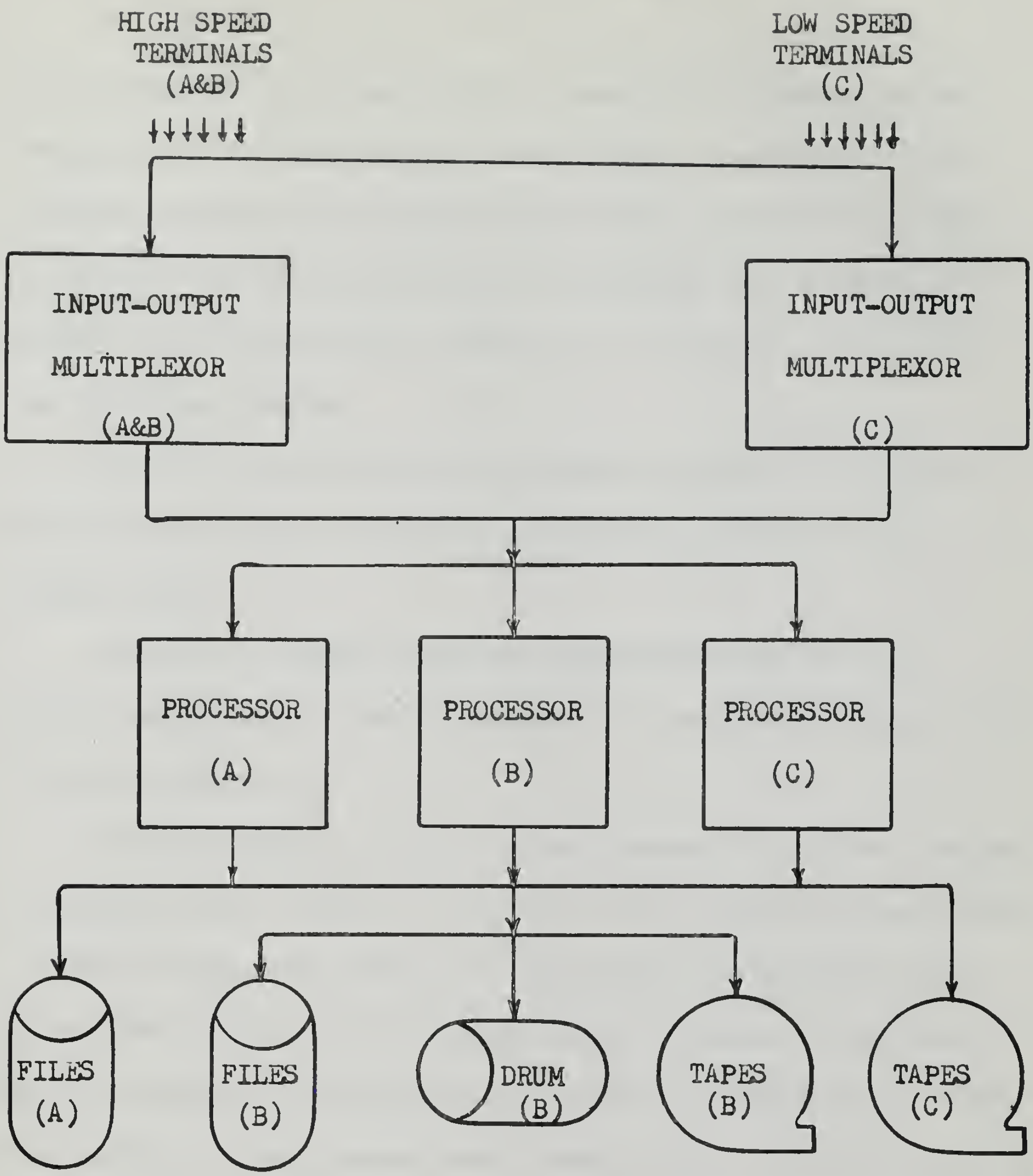


Figure 9. Multiprocessing System

Head, Robert V., "7 Configurations for Real-Time Computer Systems." Control Engineering, June 1964, p.108.

The multiplexor is a device which permits the transfer of data from several storage devices which operate at relatively low transfer rates to one storage device which operates at a high transfer rate. The multiplexor accomplishes this in such a manner that the high speed device is not required to wait for the low speed device.

When the multiplexor has processed an input, the input is then routed to one of the three processing units for later computation.

Usually the multi-processing systems are employed in a system design where there is geographical separation of the processing equipment.

Present programs run in a manner analogous to water flowing through a pipe. They go in one end of the computer system one at a time with only one task at a time being operated upon in the pipe. This method of processing causes components to be idle. By not employing the principles of multi-processing time is lost and portions of high speed memory remain idle. There are very few business programs that use all the storage space or the computational time that is available.

It is usually more feasible to maintain a queue of jobs-in-process and operate the computer simultaneously on segments of each job that are ready for processing. This method of operation will cause each individual program to require more time to be processed, but would allow the processing of more programs in a given block of time.

The subprograms handle the inputs required, outputs desired and have a method of identifying when the subprogram is eligible for processing. When the computer is idle any subprogram that is to be processed by the computer and is ready can be assigned for processing. Queueing rules for priority processing of jobs can be derived by the system designer.

Data in core storage is addressable electronically thus access times are shorter than for external devices where some mechanical movement is required. An automatic supervisory program which operates at electronic speeds vice mechanical speeds can keep up with the computer and will not unduly delay computer operations in controlling the processing of programs. The supervisory program will have its own high speed memory and programmed logic to carry out its functions of assigning tasks and updating finished jobs.

To control peak-load conditions so that real-time requirements can be met, an Executive Control Philosophy must be developed in the system to properly schedule inputs.

The term Executive Control Philosophy means nothing more than a recognition of the system's tasks in order of system priority and control of tasks in the computer. Executive Control Philosophy dictates that the list of all subprograms be scanned sequentially, executing subprograms when they are needed. After each subprogram execution, the scanning process is resumed starting with the highest priority entry. Thus, under a peak-load condition where

all subprograms may require execution, the top priority subprogram would be executed instantaneously, the next highest priority immediately following, etc. The resultant response time of each subprogram would be the sum of all previous execution times for the higher priority subprograms, recognizing that some of the higher priority subprograms may be executed more than once. If sufficient computational capability does not exist to perform all tasks required, then the only solution is to acquire additional computers.

Programming the System

In general, the number of transaction stations per processor can increase as the event frequency per station decreases.

It can be seen that the multiple stations of a system will be competing for service from the processor. Therefore, it is absolutely necessary to properly program, making allowances, to assure equal servicing for all stations, or to service in accordance with a predefined priority system.

Functions or tasks will vary from station to station and the various stations will be in different operating stages at any given time. It is possible that one or more stations may be operating on the same function or accessing the same files at the same time. The designer of the system has therefore to determine which functions can be handled simultaneously and which cannot.

The Executive Control mentioned earlier in an on-line system serves as an interface between the real-world and the computer.

The complexity of the Executive Control program depends upon the number of unrelated or independent tasks which the system is required to perform.

Real-Time versus Conventional

The best way to describe the real-time system is to compare its operations to those of the conventional computer system. The main distinction as envisioned herein between the two systems will be found in the difference between batch processing and transaction processing.

A conventional business application of a computing system involves processing a large batch of input data at one time. Usually the data has been collected over the period of time since the last batch was processed. The processing is then accomplished at regular intervals, but usually of intervals not in excess of one day. The data are usually punched into cards or paper tape and may be later transcribed to magnetic tape, or read into the computer directly from the intermediate media.

In the batch process the batch is fed into the computer and computations are made according to the designed system processing. The output from the computer is in the form of a long list of computed data corresponding to the batch of input data. The net result is the generation of a tremendous amount of paperwork that may or may not be used by the manager. This result may be caused by poor programming as well as the requirement for the generation of historical data on paper.

A typical real-time data processing system for the same business application is considerably different. Each individual would have access to a remote input-output unit located near his workplace. Each bit of data would be directly fed individually into the computer, via one of the remote input-output units. As the event occurred, the data associated with the event would be entered into the system. The necessary computations would be performed on that bit of data, individually, and records stored in the computer or on peripheral disc files would be updated. Thus, up-to-date information will always be available to any inquires. The advantage of direct access eliminates or reduces the need for special codes as in batch processing, thus ensuring a greater degree of flexibility. Errors in input data and format are flashed back to the operator at the input device assuring a timely correction.

The manager who needs any of the computed information can go to the nearest input-output unit and request exactly the information which he needs. He is assured of having the most current information and in a form which he can readily use.

IV

SOME APPLICATIONS

Military Applications

There are many agencies of the Federal Government that are currently using real-time processing as well as a few in the industrial complex of our economy. It has been estimated that more than 350 real-time process control systems are now in operations, and that as many as 4000 will be installed by 1970.[1] Of course the application of real-time processes in the military are much more prevalant in comparison with the advances made by by industry. The advances made by the military services are primarily in the command and control area.

The Aviation Supply Office has been the scene of experimental work in the area of inventory control applications through the use of the real-time techniques of computer processing. In order to aid the commodity managers and other concerned personnel at ASO a real-time inventory control system was developed on an experimental basis to provide more timely and accurate information. At the present time only repairable items are included in the system, but it is envisioned that in the near future other items of interest will be included.

[1]Desmonde, W.H. Real Time Data Processing Systems: Introductory Concepts. New Jersey. Prentice-Hall, 1964, p.9.

The first pilot system was established to provide real-time access to the high cost, repairable items. The equipment used for the experiment was built by the International Business Machine Corporation. The original equipment of the pilot study consisted of a 1401 central processing unit, a 1407 console, a 1405 disc memory, a 1403 printer and 729 tape units.[2] (Since the first pilot study more sophisticated equipment has been installed.)

All technical data for the items in this experiment were included as well as the stock status information. The tech-ical data consisted of such items as application information for any number of aircraft which the part will fit, maintenance and overhaul factors, the manufacturer's part numbers, model codes to relate items to assemblies, lead time, price information, freight classification and packing required.

The initial system performed so well that the present system was developed to handle stock status on all items and technical information on all repairable parts. The system operates so that its executive program shares the computer's time among the inquiry stations so as to allow immediate access.

The executive program allows interrogation of the files from the remote stations, while concurrently performing operations on files. Changes to technical information and to stock status are

[2] Prywes, Noah S. The Naval Aviation Supply Office Inventory Retrieval System. Pennsylvania. University of Pennsylvania. p.3.

made as batch processing operations at least daily. From this it is readily apparent that the system inputs to the file are not accomplished in the sense of real-time as defined earlier. Real-time processing occurs in the servicing the customers. Thus, when a user wants information from the system he may obtain the desired information and find that it is sufficiently accurate for his purpose. In the ASO system, retrieval by means of the Federal Item Identification Number (FIIN) is important, since within all relevant Federal agencies, the FIIN is the most universally used number. The manufacturer's part number is used for correspondence with a contractor and is necessitated by the several months gap between the time the item is added to the inventory and the assignment of a stock number.

Real-time inquiries of the file can be fulfilled in many different ways. The inquiry stations are used mainly by the commodity managers to provide stock status and technical information necessary for stock control decisions. The technical and catalog personnel also use remote units for inquiries on items in the file in order to coordinate the data of the new items coming into the file. The personnel in the weapons system support section also make use of the remote terminals to provide information on a weapons system.

The user of the inquiry station can retrieve data by typing a key word for the information desired, a part or identification number, and a few other characters. The computer will process the

inquiry and return the requested information in seconds. If it is desired, only the status of the total system is given, or the status of one certain activity.[3]

The flexibility of the retrieval system can satisfy almost any inquiry that a commodity manager or other operator would desire. The real-time capability brings the operation of the computer to the user.

Industrial Applications

One of the pioneers in the application of real-time processing is the Westinghouse Electric Corporation which developed a total real-time message switching center and inventory control application. Other companies have developed partial systems and many are now following the lead of Westinghouse to develop integrated systems. The petroleum industry is an example of the use of a real-time processing as applied to the operations of the cracking plants located in Texas for the Humble refinery and in the Texaco plant, but neither of these plants are total systems.

The functions which are most likely to demand a fast real-time response to transactions generated at input points of industrial companies are those having to do with inventory control and other applications closely related to sales. Thus, one can see that the closer the operation pertains to the customer the more

[3] "Inquiry Procedures." Aviation Supply Office, Philadelphia. p.3.

likely the need for fast response. A salesman with immediate and accurate information of inventory status and delivery capabilities may mean the difference between keeping and losing a customer. Real-time processing sytems once again appear to be the most likely candidates for improving the competitive position of the corporation.

In the following pages the system as established by Westinghouse Electric Corporation will be described in broad terms.

The heart of the system is the UNIVAC 490 real-time computer system. This high speed computer can handle simultaneous teletype transmission and reception of 100 words per minute over all 41 circuits which terminate at the computer.[4] At the same time it can be performing, concurrently, the more typical jobs for which computers are ordinarily used. The 490 computer is augmented by the Westinghouse teletype network.

The 490 real-time system contains the central processor with a 32,768 word core memory, a magnetic drum memory with a 768,000 word capacity and a disc memory with a capacity of 78 million characters.[5]

[4] "Westinghouse Tele-Computer," Westinghouse Electric Corporation, p2.
[5] Ibid., p7.

The equipment used in the Westinghouse real-time system is now in its fourth phase. The establishment of this system was made possible by the availability of large scale computers with high capacity random-access memory units.

The real-time system of Westinghouse serves the manufacturing plants, administrative and sales offices, warehouses, repair centers and distributors for the entire organization. The system as designed automatically routes over 18,000 messages per day.[6] The system automatically processes teletyped orders and performs centralized inventory control functions as well as providing the means of gathering data and performing the computations required to supply company wide information for managerial decision-making.

At Westinghouse the message switching function is a means to an end rather than an end in itself. The real-time computer would be an expensive substitute for the previously used switching equipment. The switching function is closely tied in with the other functions such as order processing, or stock status inquiries. The computer also calculates the accounting costs for each message processed and assigns them to the proper division for charges.[7]

[6]Reiser, C., "The Short Order Economy," Fortune, August 1962, p 91.

[7]"Message Switching with the UNIVAC 490 Real-Time System," Sperry Rand Corporation, p6.

When a station begins to transmit, the computer checks the address and format of the message heading. If the address and format are correct, the message is written on the magnetic drum. If the address is not valid, the message is routed to an operator in the communications room for manual handling. When a valid incoming message is complete, the computer checks the time to see if the addressee's station is open and determines whether the proper outgoing line is free. If the line is busy, then the computer makes a note to itself to transmit the message as soon as the line is free, the computer adds a serial number, date and time to the message as it is transmitted. As a check feature the message is also retained in the random-access memory so that it can be recovered for a repeat transmission if necessary.

Order messages are identified and processed automatically as they are received by the computer, with shipping instructions to the proper warehouse prepared with no intervening manual operations.

The order entry program processes all orders and inquiries and maintains the inventory records on the disc file. Stock status inquiries in this system receive top priority. The computer checks the warehouse inventory for the availability of the requested items. The answer required is returned to the requesting station in the standard format. Customer orders are processed as they are received. The orders contain the customer's billing and shipping address, the product identification, and the preferred warehouse. The order entry program searches the file to obtain

the inventory status of the item at the preferred warehouse and then sends a shipping notice to that warehouse via teletype if the item is available. For items that are not available at the preferred warehouse, the computer uses a geographic warehouse file established along the lines of the traditional transportation problem which assures the most economical move of the item.[8]

As the items are assigned to a specific order the stock records are updated taking note of the reorder level. Then for each shipping order that is generated the order entry program extracts the necessary information from the random-access file. All the necessary information is forwarded to the receiving teletype printers at the warehouse where the actual labels, bills of lading and other necessary documents are prepared.

Back orders are generated for items that are out of stock. This information is then transmitted back to the customer and the pertinent sales office.

The present system is a tremendous improvement over the old manual system which relied upon individual efforts a great percentage of the time. The present system has greatly reduced stock-outs and eliminated the manual effort of locating an item which was out of stock at one point. There is no longer any such thing as a rush order in this system. The orders are operated upon as soon as the ordering point is recognized for transmission.

[8] Westinghouse, op.cit. p.13.

Top management has grasped the possibilities of an integrated communication-computation facility which allows for an extension of the information center concept to a very broad range of applications. The computer keeps an up-to-date information file on employees, containing the name, address, location, job identification, education and experience of each employee. The computer also maintains a register of all the stockholders, calculates the dividends on each account and then prints the dividend check.

Many industrial companies are interested in the possibilities of real-time information processing systems as is evidenced by the installation of such systems in such corporations as DuPont, Hughes Aircraft, and Mead Paper company. These firms and others with a similar bent are seriously experimenting with total corporate-wide communication and control systems.[9] Figure 10 shows in general the application of computers in the various industries.

[9]Sprague, op.cit. p.128

How Companies Are Using Computers

(Percent of Companies Indicating each Application)

	Accounting	Inventory Control	Business Forecasting	Transportation	Location Selection	PERT	Production, Planning & Control	Process Control	Scientific & Engineering Applications	Data Acquisition	Other
Iron & Steel..................	100%	79%	37%	26%	5%	47%	84%	58%	63%	26%	16%
Nonferrous Metals...........	100	93	20	13	0	7	67	13	27	13	7
Machinery....................	96	90	29	5	9	28	89	23	63	16	9
Electrical Machinery..........	100	92	42	27	8	31	92	27	65	35	15
Autos, Trucks & Parts........	100	100	38	15	8	23	92	15	54	23	31
Aerospace....................	100	100	54	0	31	92	100	46	92	69	31
Other Transportation Equipment (Ships, RR Equipment)	92	92	15	8	15	38	69	8	54	8	8
Fabricated Metals & Instruments......................	91	83	39	4	13	17	65	17	39	9	30
Chemicals....................	100	76	63	34	18	39	66	21	76	24	13
Paper & Pulp.................	100	82	24	29	18	6	65	24	53	29	18
Rubber.......................	100	100	75	50	25	25	75	25	75	25	25
Stone, Clay & Glass..........	100	38	44	25	6	38	50	6	50	6	38
Petroleum & Coal Products...	100	85	70	60	35	55	75	50	85	45	20
Food & Beverages...........	100	71	32	23	16	19	39	0	35	10	23
Textiles......................	100	89	28	28	0	6	72	28	11	17	17
Miscellaneous Manufacturing	97	83	42	14	14	8	64	28	17	8	19
ALL MANUFACTURING......	98	84	39	20	13	28	73	24	53	20	18
Mining........................	100	86	38	38	14	41	76	52	62	17	0
Railroads.....................	100	63	31	56	6	6	25	0	44	31	25
Other Transportation and Communications...........	100	62	22	27	8	11	38	11	30	32	24
Electric Utilities.............	100	71	24	37	5	44	34	17	90	27	17
Commercial...................	100	40	15	7	2	4	11	4	8	10	27
ALL BUSINESS*..............	99	74	33	21	10	25	58	20	47	20	19

* Excludes gas utilities. Source: McGraw-Hill Economics Dept.

Figure 10. How Companies Are Using Computers

Electrical World, April 12, 1965, p.31.

V

WHITHER NOW

The Chrysler Corporation has completed recently a real-time system to be utilized in all their manufacturing systems for the purpose of quality control. Even though the primary purpose of the system is to provide continuous quality control via the computer which is an IBM 1710 the system also performs clerical work. The computer is used to maintain payrolls, and maintain control of the inventory of spare parts required for each run as well as to schedule the runs.

The Whirlpool Corporation uses an IBM 1001 data transmission system with Bell Telephone's Data-Phone service as part of their system for distribution of parts. The data transmission system has a punched card input which causes an identical card to be punched at the output station. The punched cards for orders are entered into an IBM RAMAC 305 computer for processing. The system is not a true real-time system as defined herein because of the manual link, which involves the transcription from soft copy to the punched card.

The preceding chapters have attempted to show the real-time system in theory and practice, in order to assess the capabilities and limitations of real-time systems for business relationships. Many of the advantages of real-time control systems have been presented briefly.

One of the main advantages of the use of real-time computer systems for inventory control is the improved service which is rendered to the customer. Clearly then, it may be stated that any system which allows a manufacturer to offer improved service without increasing costs is the result of an improvement in management albeit in the area of inventory control. Usually, improved service is accompanied by increased costs. A quantitative measure must be assigned to the benefits derived from increased service in order to compare the benefits to potential costs. In the highly competitive industries of today the ability to offer improved service can be a major factor when trying to lure more trade from the oppositon.

It then falls to the lot of management to decide whether doing something with the computer that has not been done before is worth the effort and the initial additional cost that may be entailed in the change-over. In the first instance one will find that most of the computer systems initially installed were to be used as substitutes for clerical labor. Cost justification is now no longer as easy as it was in the early stages of computer generations.

A recent issue of Business Week posed two questions which are similar to those being asked by managers contemplating a new computer installation. "What is it worth in dollars and cents to give a customer a price, order verification, and delivery date minutes after you receive the order? Can expensive materials

[illegible]

control systems result in enough savings in stock inventory to justify the cost of programming and computer time?"[1] Business Week believes that most companies do not have a clear enough conception of their own operations to answer such questions.

Aside from providing better service to the customers, real-time computer systems provide many benefits to the company, many of which are very difficult to measure quantitatively. Control of an operation implies the need for information to be fed back to the decision maker. Management information is supplied by most practical real-time systems on a current basis, enabling managers to make more accurate decisions. The management reaction time to change in all areas is speeded to the greatest degree possible. The manager is no longer tied to the historical type of information received when the system was based upon a cycle of reports.

The system as established at Westinghouse provides quicker, better, and more economical control of information. The management feels that the system though the logical step to take at the time was considered to be a tremendous move forward.

The duplication present in existing computer applications have caused firms to look to the real-time system concept as the logical solution to eliminate the inherent redundancy. It can be

[1] "New Tool, New World." Business Week. February 1964, p.81

stated here without equivocation that the future development and progress in the area of computer applications for large industries will look to the real-time system.

The most important characteristic of a real-time computer system is its ability to bring the operation of the system under the control of the user

Previously, the user of information was forced to search through volumes of data to locate the specific information required. Under the present concept of the real-time system the user of information can make an inquiry of the computer and receive the information that is desired in a matter of seconds. There is no long search process involved for the user. The management-by-exception principle is one of the basic precepts of good allocation of resources within a business and has readily lent itself to the computer applications, but more so with the advent of the real-time system.

The capability of the random-access files allows all files of information to be readily available for use at any time. The President of the Teleregister Corporation believes that the future of data processing lies in the real-time field, and that "off-line approaches will eventually be set aside because of the vast amount of hard copy and paperwork that they generate."[2]

[2] Sprague.op.cit.p.4.

Mr. Sprague goes even further than this in that he predicts that "by 1970, all electronic data processing systems will be of the on-line real-time variety."[3]

The real-time systems do not come without their disadvantages. The installation of a real-time system can cause changes in the organization structure and sometimes in the entire manner of doing business. It may even require that the operation be disrupted for a period of time. The decision to move or not to move into a new area of data processing requires top management to make new policy on matters that seem excessively technical.

The vastness of the change already brought about by computers has already begun to subtly alter the structure of power within many businesses by placing the men who understand and control computers closer to policy-making and decision-making positions. This has resulted in greater responsibility being placed upon the controller of many businesses. Thus, the controller finds himself in a position where he is involved with the problems of production scheduling, engineering, distribution planning and marketing.

Clerical and production workers have already felt the impact of the computer. Some jobs are being displaced by mechanization, while new jobs are being created. The real-time system will create many new jobs, but it will also displace many of the clerical

[3]Ibid, p.iv.

workers required under present systems.

In past years the middle management group was considered to be relatively stable with very few changes, and occasional vacancies filled by an "understudy". The role of the computer is such that the middle management group may be displaced in their function as decision makers just as the lower level workers are being displaced. The middle management group is more taken up with the task of pace setting, expediting and ensuring that standards are being met.

Also, the computer has reversed a trend which set in after World War II, which was to decentralize control within an organization. Now, with the advent of real-time systems this trend has been toward a greater degree of centralization by many of the corporations that previously subscribed to the decentralization theory. This is being accomplished by tying in outlying corporate activities to the central office via data transmission facilities. Thus, through this centralization all necessary information for top management to make intelligent decisions is instantaneously available at the central office. The firm may be decentralized geographically to the maximum extent possible yet centralized for the top management decision-making role. Frequently, this type of control is dubbed "centralized-decentralization" and has in reality been made possible through the real-time system. Thus, based on information received and analyzed, management may make the necessary decisions and have those decisions fed back into the system to complete the cycle.

The role of the computer is such that it will not only affect the working level, but will affect management, both top and middle. It can readily be seen that working relationships and job content within an organization may be drastically changed as the positions affected are filled by new personnel and certain functions are redistributed within the firm.

The real-time system will ensure that managers are kept abreast of the changes and trends of the firm and in a position to take immediate remedial action if and when necessary. In the past the top managers did not receive all the information necessary in such a timely manner as to look far enough into the future. With the real-time system the managers will be able to look into the future and analyze the alternatives available to them. By a careful analysis of the alternatives they will be able to develop long term plans that take into account many more variables than was possible before the inauguration of a real-time system.

The best managers are those who are not satisfied with a system that is operating profitably on only a routine basis. They will analyze and search for new methods to accomplish more work in the same span of time. This can be accomplished in many different ways, singly or in combination. The flexible manager must be willing to change working schedules, shift organizational units and responsibilities in order to take the best advantage of new computer techniques. The firm that remains flexible and is able to adapt to changing situations, such that a benefit accrues to the firm,

will be the firm that is successfully managed.

Because of a shifting of personnel and job functions caused by the installation of a computer facility there is an absolute need to maintain or at least develop in the personnel of the activity a sense of mobility and flexibility. Retraining, as such, is one of the most difficult tasks to communicate initially to the personnel to be displaced or retrained. Once they realize that retraining is a necessity the personnel in the program will benefit in many instances, usually by being provided better jobs.

The computer when installed and before its complete acceptance operationally is blamed for many errors that will crop up during the familiarization phase. This is one of the problem areas that are generated and must be overcome by the personnel operating the system. Thus, it is encumbent upon management to ensure that all personnel are properly trained and oriented as to the intended function of the machine and the ultimate objective to be realized through its use. Initially the individuals will resent the machine, because they will feel that the machine is placing very strict controls on them. This is one reason that the improper functions are blamed on the machine even though the inputs are derived from the personnel using the system.

Problem Areas

The present generation of computers has solved to all intents and purposes many of the inherent problems of the past and have made the instantaneous access to any one of millions of bits of

information a reality. Also, the reliability of the present generation of computers has been tremendously improved.

This increased reliability makes real-time systems completely feasible. When batch processing is involved in a computer system, down-time is not as important a factor as it would be in a real-time system. If a real-time on-line system is being utilized and down-time is experienced nothing less that a system catastrophe will ensue. It is of the utmost importance that breakdowns be avoided. In some applications the utilization of duplicate equipment has been deemed necessary for the protection of the system as in the manned-space-projects. The computer operating schedule must allow for preventative maintenance. Down-time due to malfunctioning is not acceptable in any system, and especially in a real-time system as defined herein.

In any on-line real-time system it is necessary to incorporate automatic error-checking and corrective procedures wherever possible. Of course, during the installation of the computer system there will be extensive and elaborate testing performed because once the real-time system is operating it is much too complicated to attempt to locate errors, let alone correct them. Automatic error checking is usually accomplished by using two separate parts of the same computer or two separate computers for cross-checking.

In a real-time system the problem area that is currently receiving a great deal of attention is the area of file protection. Information may be lost in many of several ways, e.g., by electrical

or mechanical failure of memory units, through accidental erasure or through physical damage such as fire or flood. The present methods of file protection involve transcribing the information on magnetic tape or duplicating the information on disc-packs. At the Aviation Supply Office, the file information is periodically transcribed from the random-access disc files to magnetic tape. From this it can be seen that the duplication of files, while necessary, to be maintained on tapes for instance, is costly and time consuming.

Normative Analysis

Before a firm or industry embarks upon the troublesome waters of real-time computing systems a careful and detailed systems analysis should be performed weighing the economic pros and cons. The real-time systems are relatively new and tend to be experimental in nature, therefore, there is a definite paucity of cost justification.

Lockheed Aircraft Corporation lists the following as areas that have resulted in direct cost savings from the installation of their real-time data-gathering system: reduced key-punching, since the information is fed in at the source in the format desired; reduction in time-keeping personnel in that the employees are able to "clock-in" to the computer through a remote unit which reads badge information; elimination of transcription and other errors which are a direct result of the reduced key-punching and handling of information; minimization of transportation time

and cost for data from factory to data center; streamlined formats for reports; inventory reductions; and the overall reduction of expediting time and effort.[4] Some of the indirect savings that have been realized at Lockheed are the utilization of a cost effectiveness program through a complete cost breakdown of jobs, and timely information being furnished to management to allow management to make decisions faster than before. In addition to the foregoing, the real-time system at Lockheed has been able to make more profitable use of computer time by completely eliminating sorting and set-up time, which required over 50 percent of the conventional computer time.

The Lockheed Aircraft Corporation, representative of the aircraft industry, has seven large scale IBM 7094s, three Control Data 1604s, for IBM 1410s, and 35 IBM 1401s. The personnel required to operate and maintain this equipment include 600 programmers, 160 system planners, 1100 operators, and 250 miscellaneous employees assigned full-time to data processing.[5]

The costs of the real-time systems are now within the reach of most corporations, however, there is always the possibility that similar firms in an industry could pool their resources

[4] Carter, N.H. "Real Time Data Acquisition and Communications at Lockheed. "Presentation at Aerospace Electrical/Electronics Conference 1963. Los Angeles, California. p.10.

[5] Business Week. op.cit.p.81.

and develop one real-time system to service the needs of all the users as has been accomplished by some of the banks and savings and loan associations. It is in the service area for small users that the development of computer service centers will prosper.

An ideal situation that is readily adapted to the real-time system is the area of inventory control. This, of course, is especially true with large corporations which have large inventories to control. By the proper control of the inventory through the use of a real-time system there is always the potential savings to be realized through the reduction of the total inventory held on hand.

Practical applications in government and industry have shown that real-time control of management systems is entirely possible. As experience is gained in the area of real-time computer systems better techniques for the most efficient application will evolve.

Conclusions

Data-input specialists should be employed more widely as a means of improving systems and the quality of data-input in the system being designed. In addition, computers themselves can contribute to better data input by incorporating input-error detection and correction routines in the computer programs and by providing error-free input for other data activities.

Data-input problems can be dealt with more effectively if data-input techniques and equipment are considered during the design of the system. Finally, plans for data-input equipment and techniques should be developed concurrently with those for the data processing equipment and system design.

An integrated on-line data processing system is practical and can be realized, but the complication of the system increases rapidly with an increase in the number of processing sites.

The following items represent the major elements contributing to the cost of an on-line system. They should be thoroughly considered when designing a system:

a.) Input-output unit specifications and their locations. On-line or off-line preparation of data into a usable form.

b.) Information record length and the method of storage and retrieval.

c.) Extent of fallback required. Methods for providing fallback must be established and tested.

d.) Number of processing sites in the system.

e.) Off-line processing requirements both those related and unrelated to the on-line processing system.

The data processing system must be properly designed so that it is an integral part of the management system. The management system will deal with problems that arise out of a

capability to manipulate information provided toward any desired end. The management system will require capable personnel who have adequate organizational authority to perform.

The system design must have built-in protection features which provide against the contingency of user damage to, or errors in, the files.

The real-time system should be designed to provide management with the required reports to properly perform its functions without being required to scan volumes of generated paperwork. The system will offer better service to customers through an immediate processing of transactions.

While there are many advantages to the real-time system, there are also disadvantages which must be considered. Of the disadvantages one must consider the organizational upheaval and the power struggle that may be generated by the men who control and understand computers. Thus, the working relationships and job content which may be drastically changed loom as major disadvantages, but even these disadvantages can be overcome in time.

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